ECE 5273/CS 5273
Test 1

Wednesday, March 13, 2002
5:00 PM - 6:15 PM

Spring 2002

Dr. Havlicek

Name: SOLUTION

Student Num:________________

Directions: This is an open notes, open book test. You have 75 minutes to complete the test. All work must be your own.

SHOW ALL OF YOUR WORK for maximum partial credit!

GOOD LUCK!

SCORE:

1. (25) ________

2. (18) ________

3. (20) ________

4. (20) ________

5. (17) ________

TOTAL (100):

1. **25 pts.** True or False. Mark *True* only if the statement is **always** true.

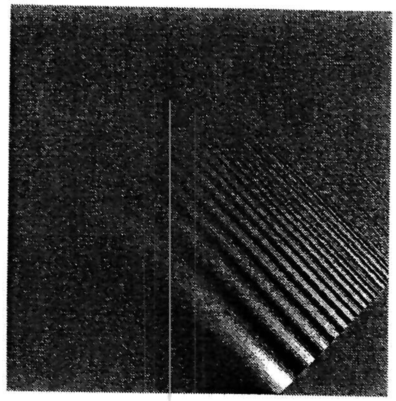
TRUE	FALSE	
✓		(a) **2 pts.** Any image $\mathbb{I}$ can be exactly reconstructed from its DFT $\tilde{\mathbb{I}}$.
	✓	(b) **2 pts.** Any image $\mathbb{I}$ can be exactly reconstructed from its histogram $H_{\mathbb{I}}(k)$.
	✓	(c) **2 pts.** Any continuous focal plane image $\mathbb{I}_C$ can always be exactly reconstructed from the sampled digital image $\mathbb{I}$.
	✓	(d) **2 pts.** The 3-D real-world scene $I(X, Y, Z)$ can be exactly reconstructed from the digital image $\mathbb{I}$, provided that the horizontal and vertical spatial pixel sampling rates are greater than the Nyquist rates.
	✓	(e) **2 pts.** Binary erosion is the inverse operation of binary dilation. That is, any binary image $\mathbb{I}$ can be exactly reconstructed by applying an appropriate erosion to the binary image $\mathbb{J} = \text{DILATE}(\mathbb{I}, \mathbb{B})$.
	✓	(f) **2 pts.** Medical CAT scans are an example of reflection imaging.
	✓	(g) **2 pts.** For viewing the DFT of an image $\mathbb{I}$ with real-valued pixels, it is usually most useful to display the logarithm of the DFT phase.
✓		(h) **2 pts.** If $\mathbb{I}$ is an image that is real and even symmetric, then the DFT $\tilde{\mathbb{I}}$ is also real and even symmetric.
	✓	(i) **2 pts.** Thresholding is usually an effective technique for separating the object and background in any image $\mathbb{I}$, provided that the histgram $H_{\mathbb{I}}(k)$ is multi-modal.
	✓	(j) **2 pts.** An image $\mathbb{J}$ is formed by applying the histogram matching algorithm to match the histogram of image $\mathbb{I}_1$ to the histgram of another image $\mathbb{I}_2$. Then, even though the two images $\mathbb{J}$ and $\mathbb{I}_2$ might look quite different from one another, their histograms $H_{\mathbb{J}}(k)$ and $H_{\mathbb{I}_2}(k)$ will be identical.
	✓	(k) **2 pts.** Run-length coding always reduces the amount of memory needed to store a ditial image.
✓		(l) **3 pts.** The instructor used to date *Lena*.

Answer should be provided "bimodal"! But this is a little unclear and I will take either answer here.

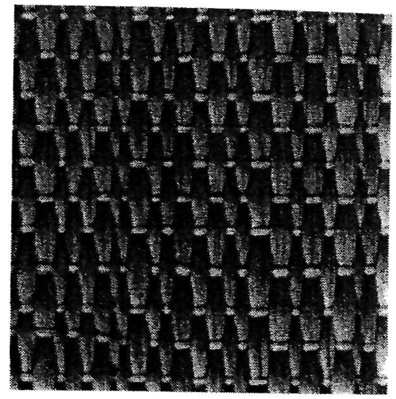
2. **18 pts**. Match the three images $\mathbb{I}_1$ - $\mathbb{I}_3$ shown below with their centered log-magnitude DFT's $\tilde{\mathbb{I}}_4$ - $\tilde{\mathbb{I}}_6$.

$\mathbb{I}_1$

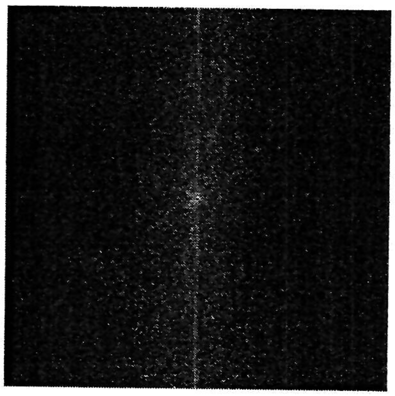
$\mathbb{I}_2$



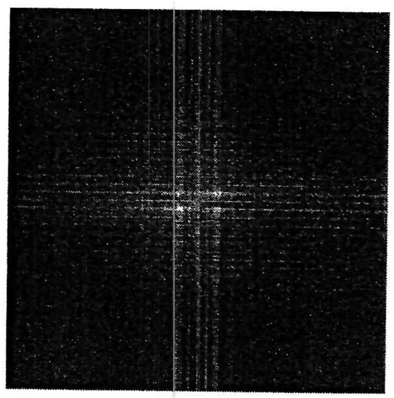
$\mathbb{I}_3$



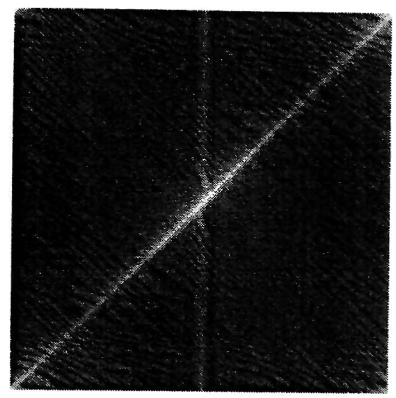
$\tilde{\mathbb{I}}_4$



$\tilde{\mathbb{I}}_5$



$\tilde{\mathbb{I}}_6$



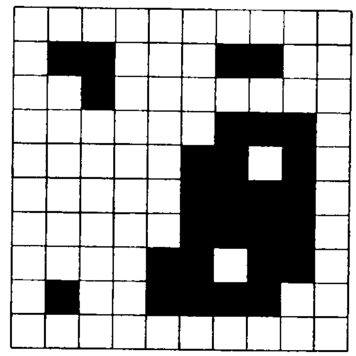
(a) **6 pts**. DFT[$\mathbb{I}_1$] = $\tilde{\mathbb{I}}_4$

(b) **6 pts**. DFT[$\mathbb{I}_2$] = $\tilde{\mathbb{I}}_6$

(c) **6 pts**. DFT[$\mathbb{I}_3$] = $\tilde{\mathbb{I}}_5$

3. **20 pts.** The 10×10 binary image $\mathbb{I}$ is shown below, where BLACK pixels have value logical ONE and WHITE pixels have value logical ZERO:

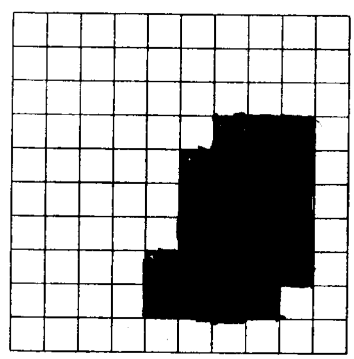
$\mathbb{I}$ =



Blob coloring with minor region removal is applied to $\mathbb{I}$ to obtain a new image $\mathbb{J}_1$, where only the largest region is retained. Image $\mathbb{J}_2$ is then defined by $\mathbb{J}_2 = \text{NOT}(\mathbb{J}_1)$. Blob coloring with minor region removal is then applied to $\mathbb{J}_2$ to obtain image $\mathbb{J}_3$. Finally, the result image $\mathbb{K}$ is defined by $\mathbb{K} = \text{NOT}(\mathbb{J}_3)$.

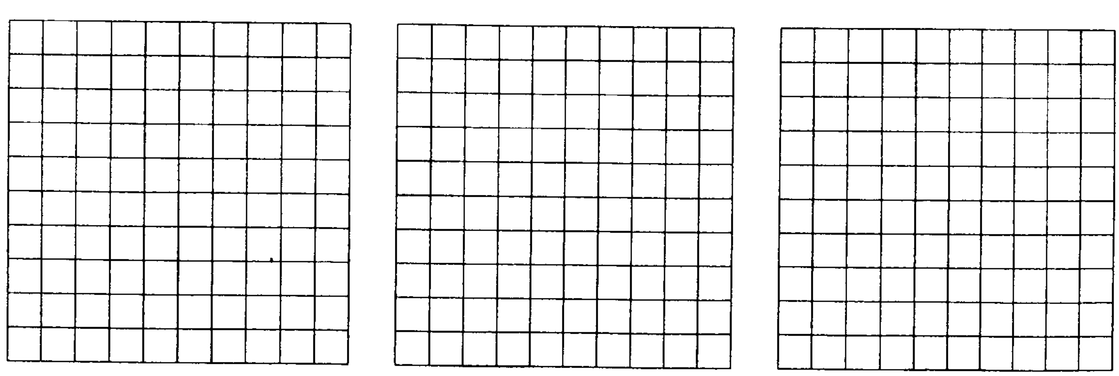
Show the image $\mathbb{K}$ below:

$\mathbb{K}$ =



Keeps the biggest blob and fills in the holes

If you need "work images," use these:



4. **20 pts**. The 256×256 image $\mathbb{I}$ is defined by

$$I(i,j) = 40\cos\left[\frac{\pi}{64}(7i+25j)\right] + 105 + 28\delta(i,j).$$

Find the DFT $\tilde{\mathbb{I}}$.

$N = 256$

$\mathbb{I} = \mathbb{I}_1 + \mathbb{I}_2 + \mathbb{I}_3$

where

$\mathbb{I}_1 = 40\cos\left[\frac{\pi}{64}(7i+25j)\right]$

$\mathbb{I}_2 = 105$

$\mathbb{I}_3 = 28\delta(i,j)$

so $\tilde{\mathbb{I}} = \tilde{\mathbb{I}}_1 + \tilde{\mathbb{I}}_2 + \tilde{\mathbb{I}}_3$

$I_1(i,j) = 40\cos\left[\frac{2\pi}{256}(14i+50j)\right]$

NOTES, P. 4.42:

$\tilde{I}_1(u,v) = \frac{(40)(256)}{2}\left[\delta(u-14,v-50)+\delta(u+14,v+50)\right]$

$= 5120\left[\delta(u-14,v-50)+\delta(u+14,v+50)\right]$

NOTES, P. 4.41:

$\tilde{I}_2(u,v) = (256)(105)\delta(u,v) = 26880\delta(u,v)$

$\tilde{I}_3(u,v) = \frac{28}{256} = \frac{7}{64}$

$$\boxed{\tilde{I}(u,v) = 5120\left[\delta(u-14,v-50)+\delta(u+14,v+50)\right] + 26880\delta(u,v) + \frac{7}{64}}$$

5. **17 pts.** Consider the 4×4 image $\mathbb{I}$ shown below, where the allowable range of gray levels is $0 \leq I(i, j) \leq 15$:

$$\mathbb{I} = \begin{array}{|c|c|c|c|}\hline 15 & 14 & 13 & 14 \\ \hline 10 & 12 & 9 & 0 \\ \hline 10 & 9 & 12 & 10 \\ \hline 9 & 11 & 15 & 15 \\ \hline \end{array}$$

Construct a new image $\mathbb{J}$ by applying the histogram flattening algorithm to $\mathbb{I}$. Show the new image $\mathbb{J}$ and its histogram $H_{\mathbb{J}}$ in the spaces provided below:

$$\mathbb{J} = \begin{array}{|c|c|c|c|}\hline 15 & 12 & 10 & 12 \\ \hline 7 & 9 & 4 & 1 \\ \hline 7 & 9 & 4 & 7 \\ \hline 4 & 8 & 15 & 15 \\ \hline \end{array}$$

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H_{\mathbb{J}}(k)$	0	1	0	0	3	0	0	3	1	2	1	0	2	0	0	3

Work Space:

$$J_1 = \begin{array}{|c|c|c|c|}\hline 16/16 & 13/16 & 11/16 & 13/16 \\ \hline 7/16 & 10/16 & 4/16 & 1/16 \\ \hline 7/16 & 4/16 & 10/16 & 7/16 \\ \hline 4/16 & 8/16 & 16/16 & 16/16 \\ \hline \end{array}$$

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H(k)$	1	0	0	0	0	0	0	0	0	3	3	1	2	1	2	3
$p(k)$	1/16	0	0	0	0	0	0	0	0	3/16	3/16	1/16	2/16	1/16	2/16	3/16